

# Emitter-Wrap Through Solar Cells with Screen-Printed Contacts

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## ABSTRACT

The Emitter-Wrap Through (EWT) solar cell is a back contact solar cell design that has potential for high efficiencies using poor quality silicon and simplified module assembly. This paper reports on a version of this device utilizing screen printed contacts. An efficiency of 15.2 % under AM1.5G illumination has been demonstrated for a 41 cm<sup>2</sup> cell.

### 1. Motivation

Back contact cells have the potential for increased efficiencies compared to front contacted cells. They also allow for simplified module assembly due to co-planar contacts. The Emitter-Wrap Through cell is a back contact cell that uses laser-drilled holes to connect the emitter from the front to the back, as seen in Figure 1. Double-sided collection gives an additional advantage of reducing demands on material quality due to double-sided collection. There are several design variations currently under development[1,2,3].

The EWT has demonstrated 18 % efficiency with a laboratory fabrication process involving photolithography[4]. Current efforts are focused on fabricating this device using low-cost processes. The process addressed in this paper is screen printed contacts.

### 2. Device Design

The laser-drilled hole spacing of the EWT determines the contact spacing (as seen in Figure 1). For screen printed metal, tolerances must be large enough for ease of alignment. A hole spacing of 2 mm x 0.5 mm was used for this device. Grid line width was chosen at 400  $\mu$ m for both N and P contacts. The percentage of p-type surface at the back was chosen at 40 %. This results in 200  $\mu$ m spacing between the edge of the P contact to the nearest N-type region on either side, and hence, this is the alignment tolerance.

The emitter was formed by the deposition and patterning of CVD oxide on the back. This

glass acts as a phosphorous diffusion mask. The patterning of the mask oxide is done by photolithography. Laser hole drilling occurs after deposition of the mask oxide and before patterning of the mask oxide.

### 3. Contacts

The N-contact metal used in these devices was screen printed silver paste, DuPont 4943. P-contact was formed either by aluminum or silver/aluminum paste. In both cases, an acceptable contact was formed as demonstrated by fill factors of 73 %. Contacts were co-fired in a belt furnace at temperatures ranging from 700 to 750C with time at peak temperatures approximately one minute.

After emitter diffusion, the contact metal pastes were printed directly on the N and P type regions without removal of either mask oxide or phosphorous diffusion glass. This was a key feature of this device. It is well known that screen printed contacts can be fired through oxides and nitrides, due to the aggressive glass frit in the screen printed metal pastes. In this device, it was also found that contamination was occurring during the belt furnace firing cycle. With only thin oxides on the silicon surfaces, contaminants were able to diffuse into the cell and decrease the lifetime near the cell surfaces. Also, it was found that the shunt conductance was unacceptably high when contacts were fired through only a thin surface oxide. The high shunt conductance was caused by contact spiking through the junction. Maintaining the thick surface oxides reduced the high shunt conductance and also acted as a diffusion barrier to contaminants during the firing cycle.

### 4. Device Results

Figure 2 shows I-V curves of 41 cm<sup>2</sup> EWT cells with screen printed contacts under AM1.5G illumination. The base material used is 0.5 ohm-cm float zone silicon. Base lifetimes are typically 5-10  $\mu$ sec after a high temperature step with deposited oxides on the surface, while 100  $\mu$ sec has been measured with samples receiving just a

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\* Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the U.S. Department of Energy under contract DE-AC04-94AL85000.

phosphorous diffusion. Lifetimes are measured by RF-PCD on a control sample using a light N+ diffusion for surface passivation. It has been determined that the deposited oxide is harming the bulk lifetime of the base material. Minimal effort has been expended to eliminate the lifetime problems, since the EWT cell demonstrates its potential most clearly with low-quality material.

## 5. Future Work

The EWT cell described here still has the disadvantage of one photolithography step for patterning of the emitter. It has been demonstrated that bare silicon surfaces give an unacceptable device quality for the EWT cell. Therefore, any emitter formation technique will have to result in oxidized silicon surfaces. Also, polycrystalline materials would benefit greatly from a gettering step. If these two process requirements can be met in a high efficiency device, then the EWT cell will become an attractive back contact cell.

## Acknowledgements

The author would like to thank Fernando Uribe and James Gonzalez for screen printing and firing, Beverly Silva for cell processing, and Jeannette Moore for cell measurements.

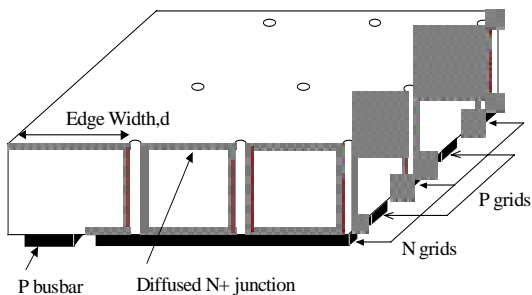


Figure 1. Emitter-Wrap Through solar cell geometry.

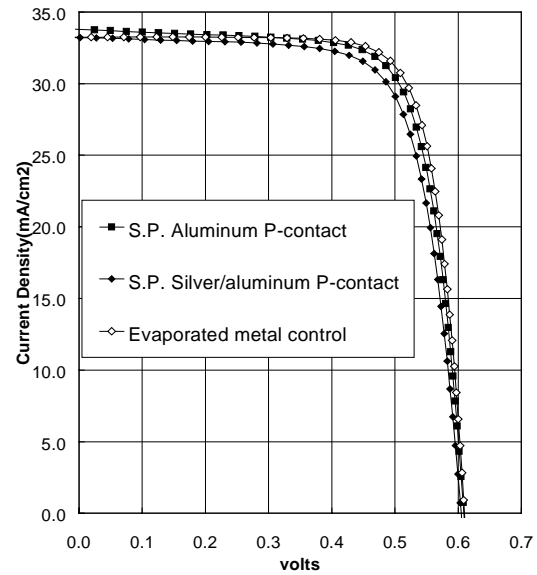


Figure 2. Illuminated current-voltage characteristics, EWT cells with screen-printed contacts and evaporated metal control. AM1.5G efficiencies of these three cells are 15.6 % for the control, 15.2 % for the screen-printed aluminum contact, and 14.6 % for the screen-printed silver/aluminum contacted sample.

## References

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